

heat not sufficient to melt the snow of the year. All the water produced is absorbed and assimilated by the ice-layers; deep temperature below zero. 2. The *glacier adolescent*. Summer heat fuses all the snow of winter, and attacks by ablation a part of the ice. All the water of imbibition is absorbed and assimilated by the ice; deep temperature below zero, even at the end of summer. 3. The *glacier senile*. Summer heat is in excess. The water of imbibition exceeds the quantity necessary to re-heating of the ice, which rises to 0° , and the excess of water flows away in the glacial torrent. Temperature of the glacier at 0° during summer.

ON May 8 three shocks of earthquake were felt at Laibach (Carniola), the first occurring at 9h. 38m. p.m., the last, at midnight, was the most severe, and, lasting two seconds; it was accompanied by a loud subterranean noise.

ACCORDING to statistics recently worked out, the number of railway travellers killed in France is one in each 1,600,000,000 km. run, which is a distance equal to 40,000 times the length of a voyage round the world. This excursion would last during 3044 years travelling day and night at the rate of 60 kilometres per hour. So that, supposing an average life-time of sixty years for a healthy man, before he could be killed by a railway accident according to the law of probabilities, he would have died fifty times a natural death.

IN the Report of the Paris Academy of Sciences for April 24 (NATURE, vol. xxvi. p. 24) the statement with regard to Prof. Ro-coe's paper "On the Equivalent of Carbon determined by Combustion of the Diamond" should read "Representing O by 15'96, C becomes 11'97." In the *Comptes Rendus* it is 11'07.

THE additions to the Zoological Society's Gardens during the past week include a Bonnet Monkey (*Macacus radiatus* ♀) from India, presented by Mr. H. B. Hamer; a Common Paradoxure (*Paradoxurus typus*) from Java, presented by Mr. F. E. Spellerberg; a Black-faced Kangaroo (*Macropus melanops* ♀) from South Australia, presented by Mr. C. T. H. Bower; two Silver-backed Foxes (*Canis chama*) from South Africa, presented by Major-General E. A. Bacon; two Long-eared Owls (*Asio otus*), British, presented by Mrs. E. Brewer; two Alligator Terrapins (*Chelydra serpentina*), a Box Tortoise (*Terrapene*, sp. inc.), a Floridan Terrapin (*Clemmys floridana*) from North America, presented by Mr. G. E. Manigault; two Beautiful Finches (*Estrela bella*) from Australia, presented by Mr. J. Abrahams; an Allen's Galago (*Galago allenii*) from Fernando Po, a Levallant's Cynictis (*Cynictis penicillata*) from South Africa, a Common Otter (*Lutra vulgaris*), British, a Swinhoe's Pheasant (*Euplocamus swinhonis* ♀) from Formosa, five White-winged Choughs (*Corcorax leucopterus*), a Spotted Bower Bird (*Chlamydora maculata* ♂) from Australia, four Common Sheldrakes (*Tadorna vulpanser* ♂ ♂ ♀ ♀), European, two Talpacoti Ground Doves (*Chamaepelia talpacoti*) from South America, purchased; a Bennett's Wallaby (*Halmaturus bennetti* ♂), an American Bison (*Bison americanus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN

THE COMET.—On May 12 the comet was within naked-eye vision, and will nightly increase in brightness. Writing from Cuckfield on May 13 Mr. G. Knott says: "The sky was very clear here last night, and I found that I could just see the comet with the naked eye, on knowing just where to look for it. I fancy that its visibility must have been in part due to the fact that its tail is pretty bright for about $\frac{3}{4}$ °. When viewed with an opera-glass its light seemed hardly equal to that of neighbouring stars rated 6'7 (i.e. 6 $\frac{1}{2}$) by Heis, and 6'5 by Argelander in D.M. In the telescope the light of the head seemed about equal to that of a 7 mag. star." This estimate by so careful and experienced an observer of star-magnitudes will furnish a reliable criterion as

to the future increase in the brightness of the comet, assuming that it follows the ordinary theoretical rule.

The following orbit has been calculated by Mr. Hind from the observations at Harvard and Albany, U.S., on March 19, one at Paris on April 11, and a position obtained at the Royal Observatory, Greenwich, on May 4:—

Perihelion passage, 1882, June 10'51851 G.M.T.

Longitude of perihelion $53^{\circ} 54' 23''$ Mean Equinox,
" ascending node... $204^{\circ} 53' 31''$ 1882°.
Inclination... $73^{\circ} 46' 23''$
Log. perihelion distance... ... $8'783187$
Motion—direct.

By a meridian-observation at Greenwich on May 12 (eight days after the last observation employed for the orbit), which Mr. Christie has caused to be reduced with every precision, the corrections to the computed place were: $\Delta\alpha \cdot \cos\delta = -9''$; $\Delta\delta = +28''$. Differential observations at the Collegio Romano, in Rome, on May 10, kindly communicated by Prof. E. Millosevich, give $\Delta\alpha \cdot \cos\delta = -20''$, and $\Delta\delta = +26''$, parallax and aberration being taken into account.

The ephemeris subjoined is calculated from these elements for Greenwich midnight:—

	R.A. h. m. s.	Decl. from Earth.	Log. dist. of light.
May 20	2 53 31 ...	+67° 15' 1 ... 9°4944	1'67
21	3 5 49 ...	65 51' 0 ... 9°4944	
22	3 16 51 ...	64 22' 5 ... 9°4946	1'92
23	3 26 46 ...	62 50' 1 ... 9°5002	
24	3 35 42 ...	61 14' 2 ... 9°5111	2'24
25	3 43 45 ...	59 35' 2 ... 9°5223	
26	3 51 2 ...	57 53' 1 ... 9°5338	2'64
27	3 57 39 ...	56 8' 1 ... 9°5557	
28	4 3 42 ...	+54 20' 6 ... 9°5800	3'18

Considering that the comet is still at a great angular distance from the perihelion and the heliocentric motion slow, the following places for the beginning of June can be regarded as approximate only:—

At Greenwich midnight

	R.A. h. m.	Decl. °	Log. distance.	Intensity of light.
June 2	4 27' 1	+44 35	9°747	6°0
3	4 30' 8	42 27	9°794	7°1
4	4 34' 5	40 12	9°845	8°8
5	4 37' 8	37 51	9°9902	11°2
6	4 41' 2	35 20	9°9965	15°2
7	4 44' 8	+32 36	0°0036	22°6

The intensity of light on May 12, when Mr. Knott made his estimate of the comet's brightness, is here taken as the unit.

At noon on June 10, the intensity of light referred to this unit is 147, and at noon on June 11 it is 154. The probability of seeing the comet near the sun on these days is not now so great perhaps as it appeared to be from the earlier orbits.

At the meeting of the Royal Astronomical Society on the 12th inst., the Astronomer Royal referred to the absence of bright lines in the spectrum of the comet, according to repeated observation at Greenwich. It will be interesting to watch the comet's development as it approaches the sun.

BINOCULAR PERSPECTIVE

THAT a near object, of small size, presents an aspect slightly different to each one of a pair of eyes directed upon it seems to have been known since the time of Euclid; but not until the present century has binocular vision been made a subject of special study.

In 1838 Wheatstone presented a communication on the Physiology of Vision (*Phil. Transactions*, 1838, Part 2, reprinted in *Phil. Magazine*, s. 4, vol. iii. April, 1852) to the Royal Society, in which he described his invention of the reflecting stereoscope, by which rays from two slightly dissimilar pictures were conveyed into the right and left eyes respectively, producing the visual illusion of binocular relief. The essential feature of this instrument he describes by saying (*Phil. Mag.*, April, 1852, p. 245): "The two pictures, or rather their reflected images, are placed in it at the true concourse of the optic axes."

In 1844 Brewster published an essay (*Edinburgh Transactions*,

vol. xv. Part 3, p. 360) "On the Knowledge of Distance given by Binocular Vision," in which he elaborated the idea that the apparent position of the combined image produced by rays, from a pair of conjugate pictures, upon corresponding retinal points of the two eyes, is determined by the intersection of visual lines passing through conjugate points. He deduced a formula and constructed a table of apparent distances, thus determined, for various values of the angle of convergence between the visual lines.

In 1849 Brewster described his invention of the lenticular stereoscope (*Phil. Mag.* 1852, p. 16) and of the binocular camera, by which slightly dissimilar pictures of the same object may be simultaneously obtained for examination in the stereoscope. Various modifications of the instruments already in use were explained, and in all of them the apparent position of the combined image was referred to the point of convergence of the visual lines, these being determined by the direction of rays on entering the eyes after reflection or refraction in the stereoscope.

In 1852 Wheatstone published a second paper (*Phil. Mag.* 1852, p. 504) on the Physiology of Vision, in which he discussed the effects of varying the angle of convergence between the visual lines, and also the distance of the pictures from the mirrors of the reflecting stereoscope. He makes no reference to divergence of visual lines, but, like Brewster, he subjoins "a table of the inclinations of the optic axes, which correspond to the different distances," which is also applicable to the binocular camera.

Direct binocular vision of a single point in front of the interocular line is the base of an isosceles triangle, whose two sides are the visual lines. Helmholtz ("Optique Physiologique," p. 93) has shown that the latter are not coincident with the optic axes, but practically they may be regarded as axial in relation to the crystalline lens. For distinction it will be convenient to call them visual axes, their intersection the optic vertex, and the angle inclosed the optic angle, as has been customary.

Let i = interocular distance,

„ a = optic angle,

„ D = distance of optic vertex from each eye,

Then

$$D = \frac{1}{2} i \operatorname{cosec} \frac{1}{2} a.$$

If $a = 0$, $D = \infty$, and visual axes are parallel.

If $a < 0$, $D < 0$, and visual axes are divergent.

Wheatstone notices the exaggeration of perspective produced when a pair of conjugate pictures, taken with a large angle between the camera axes, are viewed in the stereoscope with the visual axes nearly or quite parallel. He mentions, as a remarkable peculiarity (*Phil. Mag.* 1852, p. 514), that "although the optic axes are parallel, or nearly so, the image does not appear to be referred to the distance we should find from this circumstance suppose it to be, but it is perceived to be much nearer. It seems as if the dissimilarity of the projections, corresponding as they do to a nearer distance than that which would be suggested by the former circumstance alone, alters in some degree the perception of distance."

The last explanation is obviously inapplicable if two perfectly similar pictures can be binocularly seen as one, with parallelism or divergence of visual axis. This condition is easily imposed by placing before one eye a thin prism with its edge outward. A single object in front is seen double until the visual axis diverges enough to make the two images coincide in retinal position. To test the strength of the external rectus muscles of the eye-balls, this method has now been in use for many years by oculists. The same effect may be attained by drawing a pair of conjugate pictures apart until binocular fusion of their images ceases to be possible. Divergence of visual axes, to the extent of 8° , has been thus obtained by Helmholtz ("Opt. Phys.," p. 616), and of $7\frac{1}{2}^\circ$ by the present writer. Since this point of meeting is, in these cases, in the rear of the observer, the theory of binocular perspective held by Wheatstone and Brewster is incorrect. It is nevertheless given without qualification, either directly or implicitly, in most, if not all, of our text-books of physics.

No analysis of the phenomena of binocular vision by axial divergence has thus far been published,

Helmholtz mentions the exaggeration of apparent distance thus produced, and adds ("Opt. Phys. p. 828") that "in our visual conceptions infinity is not presented as an impassable limit." He accounts for this by stating that in abnormal vision "all we can do is to compare the sensation produced with that which it resembles most in normal vision."

By examination of a large number of stereographs and lenticular stereoscopes, I have found (*Am. Journ. of Science*, November and December, 1881) that in using them, slight axial divergence is very frequently practised. It is nearly always necessary when binocular fusion of images is obtained, in regarding stereographs by voluntarily diminishing the natural convergence of visual axes without the aid of the stereoscope. The assumption of axial convergence, as if in normal vision, is unnecessary and misleading; it should be entirely discarded in explaining vision through the stereoscope. What is really necessary is that the camera axes from corresponding points of the stereograph, at the moment the picture is taken, shall converge; and that these points shall be imaged upon corresponding points of the two retinas. The visual axis may then be either convergent, parallel, or divergent. The visual effect will vary with these conditions, but by no means in accordance with the mathematical formula given above. I have described elsewhere (*Am. Journal of Science*, November and December 1881) a method of determining approximately the apparent position of the object regarded in the stereoscope, rejecting the hypothesis that the visual axis must necessarily converge. It remains to discuss the effect of making the optic angle alternately positive and negative. Helmholtz's conclusion that the only resource, when the visual axes diverge, is to compare the sensation produced with that which it resembles most, is unnecessary. No such resource in the present case would have been needed, even temporarily, had not undue stress been laid upon the convergence of visual lines.

From the fact that a pair of similar images upon corresponding retinal points produce the same impression, as if coming from the same external point, there result two consequences of fundamental importance in binocular vision, on which depends the explanation of all vision with axial divergence. One is that both eyes are subjectively combined into a single central binocular eye, composed of two eyes coincident in position, each of them receiving its own image, which is wholly or partly superposed on that of the other. This observation is due to Hering ("Beiträge zur Physiologie," 1861, p. 35-64, or Helmholtz, "Opt. Phys." p. 777), and has been extended and applied by Prof. Le Conte (*Am. Journal of Science*, S. III. vol. i., p. 33, and vol. ii. p. 1, or "Sight," Appleton and Co., New York, 1881, pp. 213-261). The two visual lines terminating on corresponding retinal points are hence subjectively combined into a single median line, to some point of which the binocular image is referred. The apparent position of this point of sight, however, is the result of a judgment, and not a mathematical determination. In normal binocular vision the judgment of distance may accord very nearly with what might be determined by the intersection of visual lines, but there is no necessary coincidence.

The second consequence is that a point farther or nearer than the point of sight is necessarily seen double, because imaged upon retinal points that do not correspond. Conversely, if conjugate points of a stereograph are imaged upon non-corresponding retinal points, fusion can be accomplished only by changing the relation between the visual axes. To the binocular eye, therefore, such points will appear farther or nearer than the point of sight. On these two principles depends, in large measure, the perception of binocular relief.

The perception of relative distance depends upon a variety of conditions, which must be eliminated before binocular perspective is studied. There are then left still three elements to consider:—

1. The optic angle.
2. The focal adjustment of the crystalline lens.
3. The retinal magnitude of the binocular image.

The import of the first of these depends upon the relative degree of tension in the rectus muscles of the eyeballs; of the second on the tension of the ciliary muscle; of the third on the relation between the magnitude and distance of the object. The judgment of distance and size depends upon the acquired skill of the observer in interpreting the sensations due to variation of these elements. This variation is best accomplished with the aid of a modified Wheatstone stereoscope.

Let the stereoscope be so arranged that the visual axis may successively inclose every possible angle between the limits beyond which vision becomes impossible. On its arms let a pair of conjugate pictures be kept at a fixed distance each from its mirror. If the arms be so placed that the optic angle is that of normal vision, the point of sight approximately coincides

with the optic vertex, and to the distance of this the focal adjustment is adapted.

Let α = optic angle, varied by means of the stereoscope.

„ α' = optic angle of normal vision for given distance.

„ D = distance of optic vertex from each eye, determined by the formula, $D = \frac{1}{2} i \operatorname{cosec} \frac{1}{2}\alpha$.

„ D' = distance of radial point measured in the direction from which the reflected ray enters the eye. It is hence the distance of the visual image in normal vision.

„ A = distance of point of sight from binocular eye.

Under the conditions given above we have—

$\alpha = \alpha'$, and $A = D = D'$. Assume $D' = 50$ cm., then $\alpha' = 7^\circ 20'$.

If now we make $\alpha = 37^\circ 20'$, we have $D = 10$ cm. But to secure distinct vision, the focal adjustment must be adapted to D', and therefore dissociated from the axial adjustment. This to some extent antagonises the effect of tension of the internal rectus muscles, and this antagonism is increased by the fact that the visual angle remains constant. The combined effect is that $A > D$ but $A < D'$. The apparent size of the image is diminished in the ratio of A to D'. The effect of increasing the optic angle is hence to make the image appear nearer, smaller, and less deep in proportion to its area, but more distant nevertheless than the new optic vertex.

If now we make $\alpha = -5^\circ$, we have $D = -73.4$ cm., but the relaxation of the internal rectus and contraction of the external rectus muscles causes the image to appear to recede in a positive direction. This illusion is opposed by the constancy of the visual angle, and the ciliary effort to keep the focal adjustment adapted to D'. The result is that $A > D'$, and the apparent size of the image is enlarged in the same ratio, while its depth is increased still more. The effect of making the optic angle negative is hence to cause the image to appear farther, larger, and deeper in proportion to its area.

If in the discussion just given we make α the angle between a pair of camera axes, and D the distance of its vertex, while i is the distance between the two lenses, the formula is readily applicable, but α can have only positive values. The optic angle for the observer while using the stereoscope is not necessarily, or even generally, the same as that between the camera axes when the picture was taken. Apparent distance in the stereoscope is thus not determined by the intersection of the observer's visual lines, and no mathematical formula can be made to apply to the interpretation of muscular tension in the muscles of the eyes. The error into which Wheatstone fell, and which was repeated and emphasised by Brewster, consists in the application of geometry where physiological conditions are such as to destroy the value of all geometric constructions. Unfortunately this error is still repeated in most of our text-books of physics, wherever diagrams are employed to explain the theory of the stereoscope.

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SCIENTIFIC SERIALS

The Quarterly Journal of Microscopical Science for April, 1882, contains—Pringsheim's researches on chlorophyll, translated and condensed by Professor Bayley Balfour (with plates 8 and 9).—Dr. D. H. Scott, on the development of articulated laticiferous vessels (plate 10). In the plants investigated, the vessels arose from rows of cells, of which the cross walls, and where two were in contact, the side walls in part became gradually absorbed. This took place very early; when not in contact, connection took place by means of cross rows of cells, which underwent fusion, or by inoculating outgrowths, before absorption; such cells showed the probable presence of latex.—Dr. E. Klein, on the lymphatic system and the minute structure of the salivary glands and pancreas (plates 11 and 12).—Prof. F. M. Balfour and F. Deighton, a renewed study of the germinal layers of the chick (plates 13–15).—Isao J. Iijima, on the origin and growth of the eggs and egg-strings in *Nephelis*, with some observations on the "spiral asters" (plates 16–19).—Dr. A. A. Hubrecht, a contribution to the morphology of the Amphineura.—Prof. E. Ray Lankester, on the chlorophyll-corpuses and amyloid deposits of *Spongilla* and *Hydra* (plate 20). These forms are not of the nature of parasitic bodies, but they correspond in structure with the chlorophyll bodies in plants.

Journal of the Royal Microscopical Society for April, 1882, contains the President's address, by Prof. B. Martin Duncan.—

On mounting objects in phosphorus, and in a solution of biniiodide of mercury and iodide of potassium, by J. W. Stephenson.—On the threads of spider webs, by Dr. J. Anthony.—With the usual most useful summary of current researches relating to geology and botany, and the Proceedings of the Society.

Journal of Anatomy and Physiology, Normal and Pathological, vol. xvi. Part 3, April, 1882, contains—Dr. A. M. Marshall, the segmental value of the cranial nerves (pl. 10).—Dr. G. E. Dobson, the anatomy of *Microgale longicauda*, with remarks on the homologies of the long flexors of the toes in mammalia.—Dr. T. P. A. Stuart, the curled hair and curled hair follicles of the Negro.—Dr. G. Sims Woodhead, some of the pathological conditions of the medulla oblongata, in a case of locomotor ataxia (pl. 11).—Dr. M. Hay, on the action of saline cathartics.—W. J. Walsham, abnormal origin and distribution of the upper seven right intercostal arteries, with remarks.—Dr. W. Stirling, on the digestion of blood by the common leech, and on the formation of haemoglobin crystals (pl. 12).—Prof. Turner, on a specimen of *Mesoplodon bidens*, captured in Shetland; and on a specimen of *Balaenoptera borealis*, or *laticeps*, captured in the Firth of Forth.—G. S. Shattock, note on the anatomy of the Thyro-arytenoid muscle in the human larynx.

Johns Hopkins University. Studies from the Biological Laboratory, vol. ii. 2 (March, 1882), contains: W. K. Brooks, Medusæ found at Beaufort, N.C., during the summers of 1880 and 1881, and on the development of the ova in *Salpa*.—J. P. McMurrich, on—the origin of the so-called "test cells" in the Ascidian ovum.—G. M. Sternberg, bacterial organisms commonly found on exposed mucous surfaces and in the alimentary canal of healthy persons;—on a fatal form of Septicæmia in the rabbit from the subcutaneous injection of human saliva;—on experiments with disinfectants.—H. N. Martin, observations on the direct influence of variations of arterial pressure upon the rate of beat of the mammalian heart.—W. H. Howell and M. Warfield, the influences of changes of arterial pressure upon the pulse rate in the Frog and the Terrapin.—H. Garman and B. P. Colton, notes on the development of *Arbacia pustulata*.—K. Mitsukuri, on the structure and significance of some aberrant forms of lamellibranchiate gills.—E. B. Wilson, on the early developmental stages of some polychætous annelides.

The American Naturalist for April, 1882, contains—On mound pipes, by E. A. Barber.—On the flowers of *Solanum rostratum* and *Cassia chamaecrista*, by J. E. Todd.—Is Limulus an arachnid? by A. S. Packard; a criticism on the views of Prof. Lankester.—On a pathogenic Schizophyte of the hog, by H. J. Detmers.—On Mexican caves with human remains, by Ed. Palmer.—The Editor's table.—Recent literature.—General notes, and scientific news.

May, 1882, contains—The acorn-storing habits of the Californian woodpecker, by R. E. C. Stearns.—Observations on some American forms of *Chara coronata*, by T. F. Allen.—The loess of North America, by R. Ellsworth Call.—The ichthyological papers of G. P. Dunbar, with a sketch of his life by J. L. Wortman.—Problems for zoologists, by J. G. Kingsley.—Recent literature.—General Notes.—Scientific news.

Verhandlungen der k. k. zoologisch-botanischen Gesellschaft in Wien, Bd. xxi. Heft 2, 1882, contains: Josef Mik, dipterological studies, II. (pl. xvi.), and notes on G. Strobl's discoveries of Diptera at Seitenstetten.—Ed. Ritter, on the *Phaspididae* and *Scydmaenidae* of Syria; analytic key to the European Coleoptera, V. (pl. xix.).—C. R. Osten-Sacken, list of the entomological writings of Rondani (supplementary to Hagen).—J. Freyn, supplement to the flora of South Istria.—H. B. Möschler, contributions to the butterfly fauna of Surinam, IV. and end (pls. xvii. and xviii.).—A. Rogenhofer and Dr. R. W. v. Dalla Torre, on the Hymenoptera of Scopoli's "Entomologica Carniolica."—August Pelzeln, on the second package of birds sent by Dr. E. Bey from Central Africa.—Dr. L. W. Schaufuss, zoological results of an excursion to the Balearic Islands (pl. xxi.).—Dr. L. Koch, the Arachnida and Myriopoda of the Balearics (pl. xx. and xxi.).—Schulzer v. Müggengburg, mycological notes, VI.—L. Ganglbauer, analytic tables of European Coleoptera (pl. xxii.).—A. B. Meyer, on birds from some of the southern islands of the Malay Archipelago.—Johann Bubela, list of the wild plants of Bisenz in Moravia.

Archives des Sciences Physiques et Naturelles, April 15.—The grain of the glacier, by F. A. Forel.—Note on the extension of